Regions of the Electromagnetic Spectrum

Listed below are the approximate wavelength, frequency, and energy limits of the various regions of the electromagnetic spectrum.

	Wavelength (m)	Frequency (Hz)	Energy (J)
Radio	$> 1 \times 10^{-1}$	$< 3 \times 10^{9}$	$< 2 \times 10^{-24}$
Microwave	$1 \times 10^{-3} - 1 \times 10^{-1}$	$3 \times 10^{9} - 3 \times 10^{11}$	$2 \times 10^{-24} - 2 \times 10^{-22}$
Infrared	$7 \times 10^{-7} - 1 \times 10^{-3}$	$3 \times 10^{11} - 4 \times 10^{14}$	$2 \times 10^{-22} - 3 \times 10^{-19}$
Optical	$4 \times 10^{-7} - 7 \times 10^{-7}$	$4 \times 10^{14} - 7.5 \times 10^{14}$	$3 \times 10^{-19} - 5 \times 10^{-19}$
UV	$1 \times 10^{-8} - 4 \times 10^{-7}$	$7.5 \times 10^{14} - 3 \times 10^{16}$	$5 \times 10^{-19} - 2 \times 10^{-17}$
X-ray	$1 \times 10^{-11} - 1 \times 10^{-8}$	$3 \times 10^{16} - 3 \times 10^{19}$	$2 \times 10^{-17} - 2 \times 10^{-14}$
Gamma-ray	$< 1 \times 10^{-11}$	$> 3 \times 10^{19}$	$> 2 \times 10^{-14}$

URL:
http://imagine.gsfc.nasa.govfc.nasa.gov/docs/science/know_l1/spectrum_chart.html

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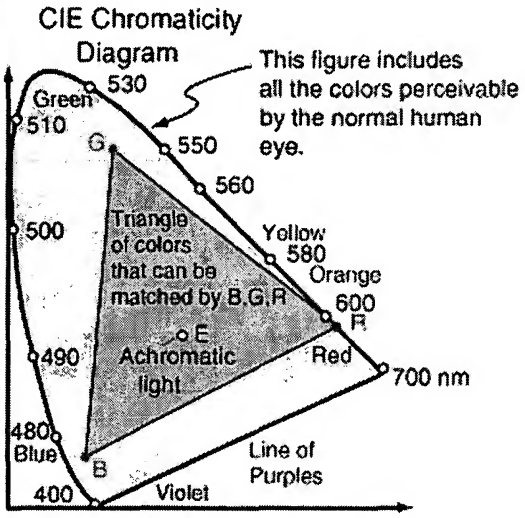
The C.I.E. Color Space



The CIE system characterizes colors by a luminance parameter Y and two color coordinates x and y which specify the point on the chromaticity diagram. This system offers more precision in color measurement than do the Munsell and Ostwald systems because the parameters are based on the spectral power distribution (SPD) of the light emitted from a colored object and are factored by sensitivity curves which have been measured for the human eye.

Based on the fact that the human eye has three different types of color sensitive cones, the response of the eye is best described in terms of three "tristimulus values". However, once this is accomplished, it is found that any color can be expressed in terms of the two color coordinates x and y.

The colors which can be matched by combining a given set of three primary colors (such as the blue, green,a nd red of a color television screen) are represented on the chromaticity diagram by a triangle joining the coordinates for the three colors.

Index

CIE concepts

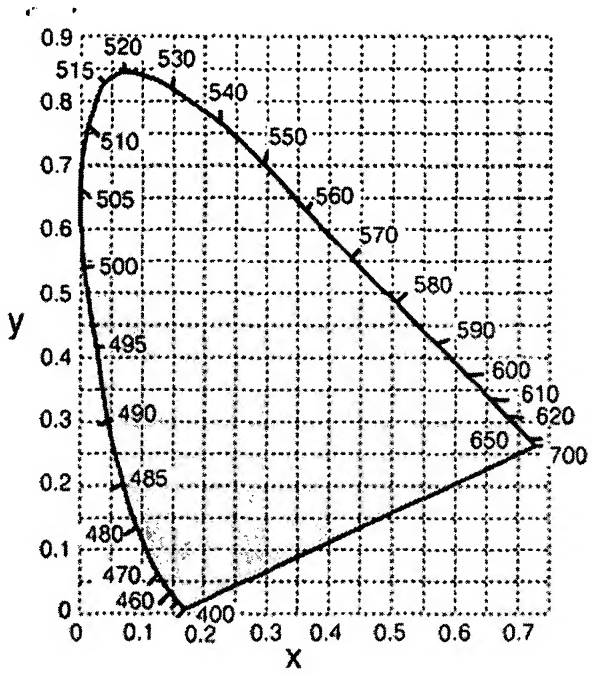
Color measurement concepts

HyperPhysics***** Light and Vision *R Nave*

Go Back

The C.I.E. Chromaticity Diagram

The diagram at left represents the the mapping of human color perception in terms of two CIE parameters x and y. The spectral colors



are distributed around the edge of the "color space" as shown, and that outline includes all of the perceived hues and provides a framework for investigating color.

The diagram given here is associated with the 1931 CIE standard. Revisions were made in 1960 and 1976, but the 1931 version remains the most widely used version.

Diagram with annotation | Associate with colors

The 1976 CIE Chromaticity Diagram

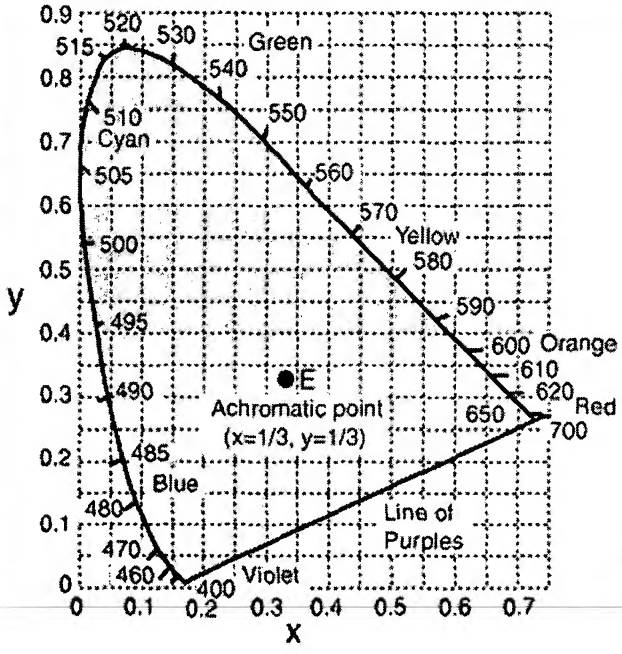
Index

CIE concepts

Color measurement concepts

HyperPhysics***** Light and Vision *R Nave*

Go Back



The C.I.E. Chromaticity Diagram

On the CIE chromaticity diagram at left, some annotation is made about the significance of different parts of the diagram. The boundary represents maximum saturation for the spectral colors, and the diagram forms the boundary of all perceivable hues.

Calculation of coordinates

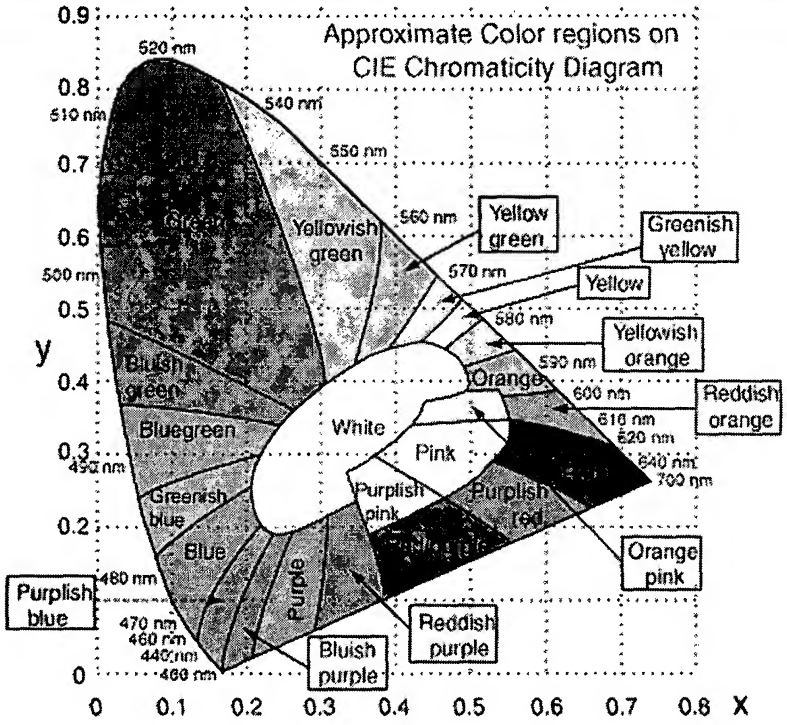
Index

CIE concepts

Color measurement concepts

HyperPhysics***** Light and Vision *R Nave*

Go Back



Approximate colors can be assigned to areas on the CIE Chromaticity Diagram. These are rough categories, and not to be taken as precise statements of color. The boundaries and the color names are adapted from Brand Fortner, "Number by Color", Part 5, SciTech Journal 6, p32, May/June 1996.

Any attempt to depict the gamut of human color vision on a computer monitor must be accompanied by numerous qualifications and exceptions. In the first place, you cannot display the range of human color perception on an RGB monitor - the gamut of normal human vision covers the entire CIE diagram while the gamut of an RGB monitor can be displayed as a triangular region within the CIE diagram. Another qualification is that the hue and saturation associated with a given color name can vary over a considerable range. Add to that the variations with different kinds of display monitors, and you rightly conclude that an accurate rendition is impossible. With all those excuses, however, it still might be instructive to provide a rough idea of the regions of the CIE Diagram associated with common color names.

Color name	Red	Green	Blue
Red	191	27	75
Pink	245	220	208
Reddish orange	216	119	51
Orange pink	240	204	162
Orange	228	184	29
Yellowish orange	231	224	0
Yellow	234	231	94
Greenish yellow	235	233	0
Yellow green	185	214	4
Yellowish green	170	209	60
Green	0	163	71
Bluish green	24	162	121

Index

CIE concepts

Color measurement concepts

The display here was created by choosing representative RGB values for the color regions from a rendition of the 1976 CIE Chromaticity Diagram provided by Photo Research, Inc. Note that one representative value in about the middle of the hue and saturation ranges was chosen for each section of the diagram. The point chosen was just a visual judgment of a representative color in the range. The RGB values obtained are listed in the table at right. A different observer would likely have chosen different points to represent the color names, but at least these values might provide a starting point for preferred variations.

One characteristic of the commonly used 1931 CIE Chromaticity Diagram that is evident even from this crude portrayal is that the green takes up far too much of the landscape compared to the number of visually different colors in the region. That was one of the shortcomings that the 1960 and 1976 revisions sought to address.

Bluegreen	95	164	190
Greenish blue	110	175	199
Blue	92	138	202
Purplish blue	88	121	191
Bluish purple	92	102	177
Purple	246	85	158
Reddish purple	196	64	143
Purplish pink	243	208	219
Red purple	175	35	132
Purplish red	209	65	136
White	255	255	255

Calculation of coordinates

HyperPhysics***** Light and Vision *R Nave* Go Back